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Pollution-ridden Asian Megacities and the Role of Environmental Technology in Pursuing Sustainable Development

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ABSTRACT

The objective of this chapter/working paper¹ is to demonstrate that large domestic corporations in Seoul, Bangkok and Jakarta are actively attempting to produce in an environmentally friendly manner not only for environmental and health reasons but equally, to increase their competitiveness in the international economy. In order to achieve this goal, we shall first clarify some working definitions and knowledge concerning urbanization and its role in the development process. Second, we shall analyze the concomitant urban environmental conditions. Our main focus shall then be on the industrial sources of environmental degradation in the megacities and we shall attempt to determine which industries are the most polluting. Finally, we shall ascertain which or what environmental technology is in use to alleviate pollution and to enhance sustainable development. The methodology for acquiring the necessary information is questionnaires/surveys of enterprises.

¹ This work is a chapter of a Phd Dissertation. At the time of writing, only the Korean case study was completed hence, information on Thailand and Indonesia may not be fully up-to-date or may be incomplete.
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Cities are the locus of productive economic activities and hope for the future, yet they face growing environmental problems and increasing poverty.2

Indeed, rapid industrialization, and high population growth - increasingly concentrated in urban areas - has meant that the traditional problems of localized pollution are growing even more quickly than they did in the West. The concentration of the industrialization process into a much shorter time span, combined with the introduction of toxic and hazardous waste-producing industries, means that the developing countries are encountering many of the same health impacts that have occurred in the industrialized countries, but at an earlier stage in the development process and at a much lower level of per capita income.3

Seoul, Bangkok and Jakarta depict diverging mosaics of these contradictory yet coexisting elements of development and underdevelopment. The rapid industrialization and urbanization of the capitals, in conjunction with their respective geographical particularities, are thwarting their environments, and populations. As C. Parasuk states, “all developed economies have passed through a stage of rapid economic growth, coupled with deteriorating resources and environment”.4 Notwithstanding, to suggest, as Parasuk does, that the unique difference between the situation faced by the industrialized world during their period of rapid industrialization-urbanization and the dilemma faced by the Third World cities today, is the current public pressure placed upon governments to act, is insufficient.5 The crux of the predicament today is that the velocity and concentration of environmental degradation magnify the vicious cycle’s impact, and this is occurring in an extensive manner all over the world.

Third World total population grew from 1.7 billion in 1950 to approximately 4 billion in 1990 while

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Third World urban population increased during the same timespan from 286 million to 1.514 billion. For comparison, “this urban population is now larger than the total population of Europe, North America, Japan, the former Soviet Union and Australasia combined”. 6 Asia’s (excluding Japan) urban population in 1990 totalled 975 million as compared to 320.5 million for Latin American and the Caribbean and 217.4 million for Africa. 7

It is expected that the most explosive urban growth rates up to the year 2025 shall be felt in Asia and Africa. Indeed, it is estimated that “between 1990 and 2025, the number of people who live in urban areas (will) double to more than 5 billion people. (A) staggering 90% will occur in the countries of the developing world”. 8 The urbanites shall thus, feel the brunt of rapid industrialization and uncontrolled urbanization’s impact on the environment.

Our current study shall focus on the three Asian capitals of South Korea, Thailand and Indonesia. These three cities are the central nervous system, and link to the global economy, of their respective countries’ economic development and industrialization. However, the current urban environmental degradation that has accompanied this economic advancement is threatening future development by impairing economic productivity and human health.

The objective herein is to demonstrate that domestic corporations in Seoul, Bangkok, and Jakarta have perceived (and felt) the negative environmental impacts of the maelstrom rapid industrialization-uncontrolled urbanization and are actively attempting to produce in an environmentally-friendly manner, not only for environmental and health reasons for the urbanites, but, equally to increase their competitiveness in the international economy. In order to achieve this goal, we shall first clarify some working definitions and knowledge concerning urbanization as well as limn the current state of urbanization in the three cities. Second, we shall establish what are the prevailing urban environmental conditions in these metropolises. Third, environmental degradation is caused by both domestic and industrial sources. Nevertheless, we shall focus on domestic industries, and determine which are the most polluting industries, in general, and in the capitals. Finally, we shall ascertain which or what environmental technology corporations are using to alleviate pollution in order to pursue sustainable development and increase their competitiveness in the international economy.

A special note for the readers of this working paper: This work is a chapter of a PhD dissertation. At the time of writing, only the Korean case study was completed hence, information on Thailand and Indonesia may

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not be fully up-to-date, or may be incomplete.

4.1 Urbanization Conditions in the Megacities

Urbanization, as an intricate web of interconnecting factors living in symbiosis and ensuring its continual growth, is influenced by the economic development and industrialization of a country. It is one of the long-run processes of structural transformation.\(^9\) Whereas industrialization leads to the development of cities, urban areas offer, in turn, agglomeration economies, economies of scale, and proximity of labour, capital and technology. Social benefits provided by cities include education, health facilities, employment, etc. These factors affect the spatial outlay of a city, the levels of productivity and the terms of trade. Economic development also affects demography by attracting migration. Government policies can equally enhance or exacerbate this localization process. Consequently, urbanization is an integral part of the development process affecting economic growth and equity.

However, a rapid industrialization-uncontrolled urbanization cycle equally produces a highly negative by-product: urban environmental degradation. The phenomenon is especially visible in Asian metropolises like Seoul, Bangkok and Jakarta. Environmental degradation not only destroys amenities but equally hinders human health and economic productivity and hence, development. Can this maelstrom be fixed and/or avoided? Can developing countries make their megacities sustainable?

Urbanization has been defined by E.M. Pernia as the rise in the proportion (% share) of the total population living in urban places. This connotes a changing balance between rural and urban population brought about by the spatial shifts (migration) of people from rural to urban areas and by differences in the rates of natural increase of population in the two areas. Hence, urbanization (is) a structural phenomenon linked to structural economic change.\(^10\)

How unique is the developing countries’ urbanization experience? Two views are put forth concerning this issue. On the one hand, it is suggested that some aspects of the phenomenon are not that much different from what Europe or North America experienced over one hundred years ago. For instance, many factors influencing urbanization such as, structural change from agriculture to industry and services which is accompanied by a shift in labour demand and supply to cities as well as increased opportunities in urban areas,

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\(^9\)See Chapter 2.
are common among the development histories of industrialized and developing countries. Equally, rates of growth of cities are comparable when considering the same development timeframe in historical perspective i.e., both developed countries in their past, and today’s developing countries experience sustained rapid growth rates of their cities.\textsuperscript{11}

Some authors suggest that

Third World urbanization experience has been fairly conventional by historical standards. Between 1875 and 1900, currently developed countries’ urban share rose from 17.2 to 26.1\%, about the same increase which took place in the Third World between 1950 and 1975, 16.7 to 28\%. While the rate of urbanization has not been exceptional, the rate of city growth has. Between 1875 and 1900, city populations in the currently developed countries rose by about 100\%; between 1950 and 1975, city populations in the Third World increased by 188\%. City growth was faster in the Third World in part simply because overall rates of population growth were faster, in both city and countryside.\textsuperscript{12}

On the other hand, there are those of the opinion that what the industrialized countries’ experienced was different from today’s developing countries’ experience. Historically, urbanization in “Modern” Europe and North America was concomitant with the Industrial Revolution. Their experiences were a long unfolding process which did not receive violent shocks. On the contrary, population growth was low or decreasing, incomes relatively high and the development and diffusion of technological innovations were relatively slow. Other elements affecting their development were: the spatial deconcentration of industry, a decrease in rural migration and the impact of the two World Wars. This relatively slow process permitted the commensurate emergence of economic, social and political institutions to cope with urbanization.\textsuperscript{13}

In contrast, the developing world has had the mature and bustling phenomenon grafted to its your states only since 1945. This rapid urbanization has been compounded and complicated by four elements. According to Beier, the increase in population growth of the XXth century is the “single most important factor distinguishing present from past urbanization”.\textsuperscript{14} This has caused large absolute population movements to cities as well as larger natural population increases within cities (infra). The second component is the increased shortage of land available to the rural poor population as cities expand more and more consuming good agricultural land. This adds to rural-urban migration (infra). Another geographical factor is the limitation of fixed territorial boundaries.

\textsuperscript{11}WRI/UNEP/UNDP/World Bank, (1996), pp. 3-4.
\textsuperscript{14}Beier, in Ghosh, P. K., (Ed), (1984), p. 58.
Migration to an unsettled new world is no longer possible. The fourth element is the international economy of the post-1945 era with universalisation, multiplication of exchanges, rapid development and diffusion of new technologies, modern transportation and communications networks. This brings the modern urban world into the rural areas of the developing world thus, creating additional urban bias. Finally, in order to have a complete picture, one must add to this overall urbanization trend, the individual historical trends which have taken place in our three case studies.

Urbanization is a highly complex phenomenon which necessitates a closer analysis of its various components and the definitions used.

The level of urbanization is the “proportion (%) of the population that is urban at a point in time” whereas the rate of urbanization is the “pace of change in the level over time”. The proportion of the population that was urban in 1995 was close to 20% for Thailand, 35.42 for Indonesia and 81.28 for Korea. As Table (4.1) shows, Korea’s level of urbanization in 1995 was higher than those of Japan and the United States. Since 1970, all three countries’ urbanization rates have exceeded those of Japan and the United States (See Table 4.2). The figures demonstrate that the three countries are still urbanizing at a fast rate and that Indonesia and especially Thailand shall continue to do so until 2030.

The rate of urban growth is the “increase in the number of people living in urban places relative to the number at the start of a given interval”. This measurement shows how fast cities within a nation are growing. As Table (4.3) indicates, Indonesian cities have been growing rapidly (4.5% in 1990-1995) and are estimated to continue on this path well into the next century. Thailand and Korea’s urban growth rates are somewhat slower (2.2% for Thailand and 2.85% for Korea in 1990-1995) though well above the American (1.24%) and Japanese (0.42) figures.

Urban growth is the consequence of three different but intertwining phenomena to wit, natural increase of urban population; migration; and reclassification of urban zones. The natural increase of urban population is the result of two factors namely, an increase in the birth rate and a decrease in the mortality rate. As shown in Table (2.1), infant mortality since 1960 has decreased substantially in the three countries. South Korea has experienced a decrease from 85/1000 in 1960 to 21/1000 in 1992. Thailand has made considerable headway from 103/1000 in 1960 to 26/1000 in 1992. Finally, even though 66/1000 births is still comparatively high, Indonesia has considerably improved from its 1960 figure of 139/1000 births. Also, life expectancy at birth has

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made substantial progress in all three countries reaching 71 years for South Korea, 69 years for Thailand and 62 years for Indonesia.\textsuperscript{18} Overall, the higher natural increase of urban population is due to progress made in hygiene and in health care.

\textbf{Migration} is an essential factor in urban growth. It is composed of two facets, rural-to-urban migration and immigration.\textsuperscript{19} However, it is the former which contributes the most to urban growth. Indeed, this migration is facilitated by two complementary forces known as “push-pull phenomena”. Individuals are “pushed” from rural areas due to deteriorating living conditions in the countryside. In rural areas, the “linkages between poverty and environment materialise through the overexploitation of resources and their consequent decreasing productivity”.\textsuperscript{20} Hence, in an effort to improve their lot, people migrate to cities.

The “pull” factor is, on the whole, highly significant in developing countries. City growth benefits from “urban bias”. Indeed, cities provide benefits which are often lacking in rural areas. For example, cities provide economies of scale and economies of agglomeration for businesses. Access to a large pool of labour is essential for businesses and this concentration in turn attracts more labour as opportunities seem greater in the cities. Social benefits such as schools, hospitals, sanitation, clean water, electricity, etc. are also more abundant in the cities as the concentration of the population decreases costs per habitant in denser populated areas. Government policies often compound this urban bias by allocating more funds to cities. In addition, capital cities are also historically the political center of a nation. They have equally become the commercial and financial centers thus, making the metropolises the central nervous system of their countries’ economic development. It is through these megacities that international trade and globalization infiltrate the countries. These cities are essential links to the international system.

Finally, rural-urban migration has a direct impact on the natural increase of the urban population. It is young adults who migrate to cities for employment and better livelihoods. Their young age (late teens to thirties) naturally contributes to increased birthrates. This also has long-term economic consequences as urban population increases thus, supplying more labour for the future.\textsuperscript{21}

\textsuperscript{18}The 1960 figures were: 54 for South Korea, 52 for Thailand and 41 for Indonesia. UNDP, (1994), Table 4.
\textsuperscript{19}In Southeast Asia, Chinese immigration is a significant factor in urban population growth. This aspect became important as early as the XIXth century. Chinese immigrate(d) mainly for economic reasons and contribute mainly to urban populations and cities’ GNP, with commerce as their preferred sector. The Chinese in Thailand are highly integrated due to the country’s cultural and ethnic background.
Reclassification of previously rural areas to urban areas is the third facet of urban growth. As cities expand, governments have administratively enlarged municipalities in order to encompass the urban population. Hence, historical cities like Bangkok and Jakarta have expanded into highly dense Extended Metropolitan Regions (EMR).

The Bangkok Metropolitan Area (BMA) includes Bangkok, and the provinces of Phra Nakhon and Thonburi. The BMA is in addition part of the new Bangkok Metropolitan Region (BMR: BMA, Nonthaburi, Pathom Thani, Samut Prakan, Samut Sakhon and Nakhon Pathom). In Indonesia, JABOTABEK encompasses Metropolitan Jakarta (DKI-Jakarta i.e., Capital City Special Region or Daerah Khusus Ibukota) and the districts of Bogor, Tangerang and Bekasi. The Seoul metropolitan area has equally come to encompass a larger area including the cities of Anyang, Puch‘you, Syongnam and Sumon.

Reclassification equally attempts to allow city authorities to control natural resources commensurate with the populations for whom they need to supply services. However, often, natural resources, such as water sources i.e., rivers, lie well beyond the metropolitan government’s jurisdiction. This creates additional difficulties as different agencies attempt to cooperate to supply services.

A characteristic of Asian developing countries is the concentration of population and economic development in one, or a few large cities, most frequently the nation’s capital. This phenomenon is known as urban primacy. The exact figures for the primate cities’ share of urban population vary according to which classification (city, or EMR) is used. According to the United Nations’ 1995 estimates, Bangkok had an urban primacy of 56.3%, Seoul, 31.8% and Jakarta 12.3% (Table 4.4). Bangkok has the highest primacy rate in Southeast Asia, excluding city-states, and not only contains a high proportion of Thai urban population but also the majority of Thai economic activity. Indeed, according to one estimate, the BMA accounts for 12% of total population; it englobes 86% of Thailand’s GDP in the areas of banking, insurance, real estate; 74% of industrial production with over half of the country’s 52,000 industries and 23 industrial estates; 64% of public administration and defense spending; and one third of national GDP. This distribution is still highly centralized.

22The 7th National Plan (1992-1996) has introduced a new urban concept: the extended BMR which includes the BMR, the Changwad (administrative districts) of Ayuttaya, Chachoengsao, Chon Buri, Lop Buri, Petchaburi, Ratchaburi, and Rayong.
around the city of Bangkok, though it is progressively moving to the outer provinces of the BMR. Indeed, it was estimated in 1989 that the BMA and the province of Samut Prakan had 43.6% of economic activity and population within its borders. The remaining four provinces of the BMR had 31.6%.  

Jakarta, located on the island of Java, is equally a primate city. Indeed, the metropolitan area accounts for “as much as 7 percent of Indonesia’s GDP, 17% of domestic industrial production, and 61% of its banking and financial activities”. It should be stressed that Java itself contains 75% of Indonesian industry. Also, “four cities alone (Jakarta, Surabaya, Bandung and Semarang) account for 36% of Java’s -and 27% of Indonesia’s - total industrial output”. Population is equally concentrated on the island. It is estimated that Java shall “have to accommodate, on average, as many as 1.5 million additional urban residents a year over the next three decades, adding substantially to the congestion and environmental pressures - already quite evident - in its main urban centers”.

Seoul is the site of over 20,522 manufacturing companies and 121,257 services companies. These enterprises had, in 1995, over $60.6 billion in export volume. Seoul’s GDP currently accounts for 25.1% of the country’s GDP. Hence, the significant role these cities play in national economies but equally, as a link in the international system.

Megacities are those with a population of 8 million or more by the year 2000. In 1950 this definition was only applicable to two cities in the world namely, New York City, with a population of 12.3 million, and London, with 8.7 million people. In 1990 the number of megacities had reached 21, 16 of which were in the developing world. By 2015, 27 out of the expected 33 megacities in the world shall be in the developing world.

The three cities under study are members of this special group, though the exact numbers vary according

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29World Bank, (1994cra), pp. 16, 20. Java has 60% of the population and 70% of irrigated agriculture, which has significant implications for water use and distribution between population, industry and agriculture.
to classifications used. Bangkok had around 7.16 million people in 1990 and is projected to reach 10.26 by the year 2000. The population density of Bangkok is 3,500 persons per km². Jakarta’s population was estimated at 9.42 million in 1990 and is estimated to reach 13.23 million by the year 2000. Population density in the DKI area varies between 10,000-30,000 persons per km². Seoul’s population in 1990 was estimated at 11.33 million and is expected to reach almost 13 million by the turn of the century. (The Greater Seoul Area has a population of 15 million people.) Population density is equally quite high with approximately 18,000 persons per km².33

Urbanization can have both positive and negative effects on the environment. Though we shall now focus on the negative aspect i.e., urban environmental degradation, the tremendous positive effects such as improvements in health, and increased access to health services and education, should not be forgotten or disregarded.

4.2 Environmental Degradation in the Megacities

Environmental problems are caused by, and vary according to, such factors as topography, meteorology, demography, industrialization, socioeconomic development, the city’s size and rate of growth and the national and local institutional capabilities and policy implementation.34 After a brief analysis of these different facets of Seoul, Bangkok and Jakarta, we shall then proceed to limn the current environmental situation in the three cities by focusing on air pollution, water pollution and wastes. Finally, estimated costs of urban pollution are examined. It should be noted that obtaining comparable data across countries is an arduous task and one which is not always feasible due to different standards or lack of data in general.

Natural factors such as topography and meteorology, are the foundation of cities and their development. For example, the proximity to the ocean front, the fluctuations in the river levels, the flat marshy and unstable lands (weak substratum and close water tables) of Bangkok and Jakarta have affected the spatial outlay of the cities.

Bangkok is located 25 kms from the sea. The altitude of the megacity does not exceed 2 meters. The average altitude is 1.1m which means that it is approximately 0.8m above the average level of the Chao Phraya


River. The city is consequently, permanently vulnerable to the seasonal fluctuations (monsoon rains) of the river’s water level. The area is equally exposed to tides which can go upstream, bringing with them salinity. This is not unique to Bangkok. Jakarta was founded at the mouth of the Ciliwing River and the metropolitan area is divided by five rivers.

Even though Seoul is located on a very large river, the Han River, not far from the Yellow Sea, its natural environment differs from the other two megacities thus, adding other factors to its environmental situation. Seoul is surrounded on three sides by mountains (70% of Korea’s territory is mountaneous; the fourth side being the Yellow Sea) and is not geographically located in the tropics. In general, Korea’s “steep topography and seasonally distinct rainfall pattern give Korean rivers extended periods of low flow broken by extremely high flow peaks, causing flooding problems in the densely developed valleys”.

Nevertheless, many other factors (infra) contribute to making the environmental problems in all three cities very similar. We have already mentioned the high population densities of the primate cities as well as their sizes and rates of growth.

The environmental impact of economic growth depends on the scale of economic activity, the structure of economy, the efficiency of input-use and the types of technologies in use. Rapidly industrializing countries feel the impact of economic growth in a considerable manner. For instance, between 1985-1995, Korea “experienced increases in industrial production (144%), primary energy supply (171%) and road traffic (193%) much higher than the corresponding OECD averages”. This has improved people’s welfare yet it has equally taken its toll on the environment. In addition, industrial concentration in one area, i.e., a primate city, must be included in this list of factors.

Another element determining pollution is the vintage of capital equipment used. Indeed, “newer equipment is likely to be less polluting because it generally generates less waste and, new production technologies, most of which have been developed in industrial countries in response to stringent pollution

Canals, or “klongs”, play a fundamental role due to their various functions of irrigation, drainage and circulation. During monsoon rains, the klongs in Bangkok are closed to protect the living quarters and agricultural areas. However, this causes evacuation problems.


OECD, (1997), Environmental Performance Review of Korea, ENV/EPOC/GEP(97)2, p. 27. Korea’s mean annual precipitation is 1,276mm but can fluctuate between 750mm to 1,700mm per year.


OECD, (1997), Environmental Performance Review of Korea, p. 81.
control laws, are more likely to embody waste minimization techniques”.40 Hence, the “latecomer’s advantage” (infra Chapter 7).

The main atmospheric pollutants in Bangkok are SO2, NOx, CO2, lead, SPM and smoke.41 “In 1991, the industrial sector alone was responsible for 56% (251,000 tons) of the nation’s total SPM emissions. It also releases 22% (208,500 tons) of SO2, 23% (25,200 tons) of CO2, and 12% (70,000 tons) of NOx”.42 The monitoring stations in the BMR indicate that SPM concentrations have continuously risen and that the standards are consistently violated. With regard to SO2 and NO2, it appears that the current, limited, monitoring sites cannot rule out concern for these pollutants. Other air toxics which are considered to be high are benzene, butadiene, ethylene and formaldehyde.43

Also, in Thailand, the national daily standard for lead is 10 microgram/cm3. Monitoring data (9 sites) show that there was a decrease in ambient lead levels after the introduction of low leaded and unleaded gasoline in 1992. However, “blood lead levels in children and adults are among the highest in the world”.44 It has been estimated that Bangkokian children “lose an average of 4 or more IQ points by the age of seven because of elevated exposure to lead”. Excessive lead in the bloodstream is also the source of 200,000-500,000 cases of hypertension causing 400 deaths per year in Bangkok.45

In Jakarta, “ambient levels of particulate matter exceed health standards at least 173 days per year. Vehicle emissions constitute the most important source of harmful pollutants (44% of particulates, 89% of hydrocarbons, 73% of nitrogen oxides, and 100% of lead)”.46 Air pollution causes respiratory diseases and in Jakarta, “respiratory tract infections account for 12.6% of mortality” which is more than twice the national average. It is estimated that a reduction of airborne particulates in Jakarta to the level recommended by the WHO could prevent 1,400 deaths in the megacity, or 2% of annual deaths. In addition, following such standards would “prevent 600,000 asthma attacks and 125,000 cases of bronchitis in children each year”.47

Ambient lead levels in

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41Concerning SPM: “The most dangerous pollutants appear to be small particles under 10 microns in diameter, which can be easily breathed into the lungs”. Sources of these small particles are mainly from: motor vehicles, coal-fired plants and boilers and certain manufacturing industries. See, WRI, et al., (1996), p. 46.
46WRI et al., (1996), p. 6
Jakarta are 3 to 4 times higher than health standards allow.⁴⁸

Improvements in Korea’s air quality have been made for S02, SPM, HC and C0. Indeed, between 1990-1995 S02 decreased by 5% per year, though it actually increased by 13% if one takes the period 1985-1995. Approximately 48% of S02 originates in industrial combustion and processes and 22% from electricity production. SPM for 1995 was estimated to be 3% less than in 1990. Carbon monoxide decreased by 44% between 1990 and 1995. HC equally decreased by a large percentage. However, there have been significant increases in N0x and C02 emissions. N0x increased by 25% for the period 1990-1995, or by 60% if the period from 1985-1995 is used. C02 emissions increased by 53% since 1990, or by 125% since 1985. Between 30 and 35% of these emissions are generated by industry.⁴⁹

The quality of Seoul’s air has been regularly monitored by the government since 1981. The data shows that air quality has been improving since 1980, though the rate of improvement declined in the late 1980s. Annual average concentrations of S02 and SPM have decreased over the years. There has been no real improvement in concentrations of N0x in Seoul and the pH value for acid precipitation is below the normal borderline value of 5.6, at 5.4 in 1993 and 1994.⁵⁰ However, ozone and C0 have increased. The mean annual concentration of ozone in Seoul increased from 18 to 26 ug/m³ between 1990 and 1995. Smog occurred on 49 days in 1994.⁵¹ The main sources of air pollution are motor vehicles, energy consumption including households and industry. The government has implemented policies to curtail pollution such as use of cleaner energy, catalytic converters since 1987, and unleaded gas since 1990.⁵² Also, since 1992, asbestos vehicle brake pads have been substituted with other substances in order to prevent asbestos dust pollution.⁵³ Nevertheless, industries and vehicle ownership increases considerably each year thus contributing to pollution loads.

Two air pollutants are of both local and global concern. Ozone is propagated when “nitrogen oxides, carbon monoxide and hydrocarbons react with sunlight, a process that takes 8-10 hours”.⁵⁴ Fifty countries were ranked according to the highest industrial emissions of carbon dioxide for 1992. Of these, the United States ranked first as the biggest emitter of CO2 at 4,881,349 million metric tons (mmt). China ranked second with 2,667,982 mmt. The three countries under study herein ranked 16th for South Korea with 289,833 mmt; 23rd for

⁴⁹OECD, (1997), Environmental Performance Review of Korea, pp. 41, 81.
⁵¹OECD, (1997), Environmental Performance Review of Korea, p. 43.
⁵³OECD, (1997), Environmental Performance Review of Korea, p. 47.
Indonesia with 184,585 mmt; and 31\textsuperscript{st} for Thailand with 112,477 mmt.  

Much controversy exists concerning the costs and benefits of cutting greenhouse gas emission. The abatement of GHGs should reduce global warming thus, decreasing any damages related to “coastal inundation from rising sea levels, disruption of rainfall and therefore, water use patterns, agricultural effects due to heat stress, and ecosystem damage such as loss of biodiversity and habitat disruption”.  

A number of studies have estimated that if the level of CO\textsubscript{2} concentration doubles compared to its preindustrial level, it shall lead to an average of 2.5 degrees increase in temperature. The estimated cost of this rise is 1-1.5% of GDP per year in developed countries and 2-9% of GDP per year in developing countries. The costs to islands and coastal areas shall be more acute. This is highly significant for coastal cities like Bangkok and Jakarta.

The quality of water is equally essential as life depends on this source. Water for the megacities is mainly drawn from the rivers running through the capitals as well as from groundwater pumping.

The Chao Phraya River which flows through the BMR is characterized by low dissolved oxygen conditions, especially from its mouth in Samut Prakan (km 0) up to Nothaburi (km 62). The most polluted area is that situated between the Klong Toey Port (km 30) and Memorial Bridge (km 48). This stretch of the river is expected to be completely anaerobic by the year 2000 if nothing is done to alleviate pollution. 1992 data show that from Bangkok down to the mouth of the Chao Phraya River, ambient standards for lead, chromium, ammonia nitrogen, and nitrates were all exceeded. Heavy metals and ammonia are also found in the upper part of the river close to industrial sites. However, it appears that in the middle section, from where Bangkok gets its drinking water, none of the standards are violated. Treatment plants filter the water and provide clean water to 85% of Bangkokingian residents. Nevertheless, at least 15% of the people use polluted water which requires additional energy use as water must be boiled.

A very alarming case is the water quality of Jakarta Bay. Indeed, in Jakarta Bay, where untreated industrial wastes are discharged by some 30,000 small industries such as batik factories, heavy metal accumulations are alarmingly high. In fact, shrimp taken from Jakarta Bay have levels of

\textsuperscript{39}World Bank, (1994crb), p.34.}
mercury contamination second only to those of shrimp taken from Minamata Bay in Japan.

The Han River, which provides Seoul with its drinking water, has been a major focus of the government. Water quality of the river deteriorated until 1984 when it reached a high of 6.7 BOD. The following year the Biological Oxygen Demand decreased to 4.7 and finally reached 3.4 in 1990.

Aquifers are suffering on two accounts. First, directly from pollution, as toxic chemicals and waste leach into the groundwater. This has a direct impact on human health as water is pumped for human consumption. Also, aquifers suffer from overextraction, land subsidence and salinization. Water extraction is widespread in Jakarta and Bangkok. In Jakarta, at least 30% of the population relies on groundwater pumping for its needs. Total groundwater extraction for Jakarta is approximately 300 million m³/year. This exceeds the annual recharge capacity of the underlying aquifers which is only 114 million m³/year. Land subsidence occurs at a rate of 4-9 cm a year thus, affecting any piping and superstructures as well as increasing flooding possibilities. It is estimated that certain areas of Jakarta have sunk 30-70 cm in the past 15 years. Bangkok overdraws water from its water tables by a conservative estimate of 0.6-0.8 million cubic meters per day. A quarter of this water is used by the population for drinking water. Overextraction of groundwater has engendered land subsidence ranging from 5 to more than 10 cm per year throughout the region.

The proximity of Bangkok and Jakarta to the coastline coupled with tremendous groundwater pumping, facilitates salinization of aquifers. Indeed, it is estimated that the salinised area in the Northern parts of Jakarta is expanding at a rate of 0.5-1 km per year and currently extends 15 kms south from the coast.

Other elements affecting the quality of urbanites’ water sources are whether or not cities have efficient sanitation systems and whether industrial and domestic wastes are treated. Jakarta is lacking a complete modern sanitation system. Indeed, on the whole, the sanitation system still consists of an open ditch system in which all wastewater is evacuated. “In 1989, an estimated 200,000 cubic meters of wastewater per day, largely untreated,

was disposed of into the city’s water ways”\textsuperscript{68}. This has a direct impact on human health. For instance, “diarrhea is responsible for 20% of deaths for children under age 5 in Jakarta”\textsuperscript{69}. In Bangkok, there is no central sewage system.\textsuperscript{70} Consequently, human waste is channeled into septic tanks and cesspools while effluents are routed into the canals or stormwater drains.

Sewerage systems did not appear in Korea until the mid-1970s. The percentage of the population connected to sewerage system varies according to the city. Seoul has a very high rate of 95%. However, there then is the question of sewerage treatment which is targeted at 55% for 1997. Sewerage sludge is for the majority landfilled. A second means of disposal is dumping in the sea. Very little sludge is composted for farming use.\textsuperscript{71}

Industrial/hazardous and solid wastes are polluting the megacities. Industrial wastewater from industrial complexes has caught the Korean government’s attention since 1987 at which time the government budget financed the construction of treatment plants. Users are charged for the expenses.\textsuperscript{72} Industrial waste per unit of GDP in Korea is 80 kg per $1000. Also, industry generates 67% of Korea’s “general” waste.\textsuperscript{73} Most of the waste is picked up so there is less of a problem of informal dumping. However, still approximately 15% of total industrial effluent is discharged into the Han River and its tributaries.\textsuperscript{74} The Han River has equally had an increase in the concentration of total nitrogen and phosphorus. Total nitrogen rose from 2838 to 5424 ug/l and total phosphorus from 116 to 261ug/l between 1989 and 1995.\textsuperscript{75}

In Thailand, “the share of the non-hazardous waste generating industries in industrial GDP reduced from 71% in 1979 to 42% in 1989, and that of hazardous-waste generating industries doubled from 29% to 58\%”.\textsuperscript{76}

\textsuperscript{68}WRI et al., (1996), p. 6.
\textsuperscript{69}WRI et al., (1996), p. 6. Five million children are estimated to die annually of diarrheal diseases in the developing world, p. 36. The second most common cause of child mortality is respiratory infection.
\textsuperscript{71}OECD, (1997), Environmental Performance Review of Korea, p. 37.
\textsuperscript{73}OECD, (1997), Environmental Performance Review of Korea, p. 55. General waste as opposed to specified, hazardous waste which is only 3% of total waste. Households, commercial activities, restaurants and small businesses contribute 33% of general waste.
\textsuperscript{74}OECD, (1997), Environmental Performance Review of Korea, p. 30.
\textsuperscript{75}OECD, (1997), Environmental Performance Review of Korea, p. 30.
This compositional reversal is highly alarming for the Bangkokian urbanites. An unfortunate example is the fire and explosion in a Bangkok warehouse in the Klong Toey port on March 2, 1991. During the fire, unaccounted chemicals spewed into the waterways of Bangkok.

The Indonesian BAPEDAL defines hazardous waste as “any waste containing dangerous and/or toxic material because of its nature and/or amount, may directly or indirectly damage or; pollute life or the environment and endanger the health of humans.” According to estimates, Java and DKI Jakarta produce 225 million tons of toxic waste annually. However, the Center of Industrial Toxic Waste Management (in Cileugsi) has a capacity to treat 90 million tons per year. In reality it only treats 10 million tons per year. Hence, the remaining 215 million tons per year are left untreated by the center. The question being of course: what happens to this mountain of toxic wastes? Illegal dumping is most certainly a problem facing the government and the surrounding population.

Dumping of solid wastes onto land or in rivers and canals equally contributes to water (leachates, direct contamination) and air pollution (decomposition, burning). It is estimated that in Jakarta, 40% of waste is disposed of in informal sites and that 30% finds its way into rivers and canals. A significant portion of garbage in Bangkok is equally disposed of into the canals. Pollution has become so concentrated that the canals resemble septic canals.

Korea is experiencing waste problems similar to those of developed countries i.e., per capita waste is increasing. A Korean generates approximately 1.3 kg of waste every day or 390 kg per capita in 1995. For comparison, 730kg/capita is generated in the USA; 410 kg/capita in Japan; 560 kg/capita in France; and the OECD average is 510 kg/capita. In 1989, “only 1.9% of municipal wastes were incinerated and only 2.9% of them were recycled. Therefore, 93.9% of total municipal wastes were buried at landfills”. Unfortunately, these landfills were for the most part, not sanitary landfills but, open dumping sites.

Finally, another element affecting the quality of water is water management. Water management problems are due to unclear property rights, underpriced water, inefficient water systems, polluted waters, increased salinization and land subsidence due to excessive groundwater pumping. There is equally the difficulty in using environmental emission standards on concentrations of total load of BOD rather than absolute

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80 OECD, (1997), Environmental Performance Review of Korea, p. 55.
81 OECD, (1997), Environmental Performance Review of Korea, p. 56.
Companies may add water to their effluents in order to reduce the concentration level while the absolute level remains high. In addition, water is wasted.

Inefficient water systems often generate unaccounted-for water i.e., “water treated and distributed at public expense but that is not accounted for by sales”. This is relatively a high phenomenon in the three megacities. For 1990-91, over 30% of water supply was unaccounted for in Bangkok; over 40% for Seoul; and above 55% in Jakarta.  

The environmental problems of the megacities are multiple and vast and are costing the people, the industries and governments. However, the economic costs of environmental degradation are only beginning to be the subject of research. These costs include items such as medical costs, lost worker productivity, loss of amenities, loss of leisure time, future loss of adult productivity for children exposed to high levels of lead, time lost collecting, purifying water etc. A simple example is water quality: “in Jakarta, households spend more than $50 million per year to boil water for drinking -an amount equal to 1% of the city’s gross domestic product”.  

A health benefits model was devised to estimate the health benefits of a 20% improvement in air quality including the following pollutants: SPM, lead, NOx and ozone. The results show that the highest benefits for Bangkok would come from reductions in SPM and lead. Health benefits (in 1989 US$) from a 20% reduction in these two pollutants would range between $737-3,102 million or a per capita between $95-399. For congestion, the (World Bank) study estimates that a 10% reduction in peak-hour trips would provide benefits of about $400 million annually”.

Another study focused on the health effects and economic costs of pollution in Jakarta. These effects and costs were estimated at US$523 million in 1990. This is broken down into approximately US$220 million for air pollution and US$303 million for water pollution.

Finally, the costs/losses due to trafficjams were also estimated for the three cities. The annual cost of time delay for Bangkok is US$272 million or 2.1% of regional gross national product; $154 million or 0.4% for Seoul; and $68 million or 0.9% for Jakarta.

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87World Bank, (1994cra), p. 89. These are central figures. The total air and water pollution low estimate was US$138 million and the high one was at US$1,131 million.
88WRI, et al., (1996), p. 25. For comparison, it is estimated that the United States loses 2% of its GNP due to trafficjams, and the United Kingdom, 5% of its GNP.
As more and more studies on urban environmental degradation are undertaken it appears that a general conclusion shall be reached: pollution is costly. It is the dissemination of this information as well as subsequent action which are primordial in order to curtail environmental degradation and to develop measures to make these megacities sustainable. This is especially true as the urbanization trend shall press onwards into the 21st century.

4.3 Industrial Environmental Degradation: Who are the Culprits?

Environmental degradation is engendered by two main sources namely, domestic and industrial sources. An example is domestic wastewater in Jakarta which “contributes 80% of surface waste pollution” in the megacity. However, industrial discharges of toxic waste is on the rise.

The focus of this study is on industrial sources of pollution. Why do we focus on industry rather than domestic sources of pollution, since it has been stated that “it is the unsanitary conditions in the home and neighbourhood (which) are generally more of a threat to health than industrial pollution”?

First, because the provision of infrastructure - sanitation, water piping, public transportation- fall, on the whole, under public authority. The inability and/or unwillingness of local authorities to provide basic infrastructure and needs are major stumbling blocks in overcoming domestic sources of pollution. Second, industrial pollution is increasing in the megacities as more and more firms are locating in the cities to gain from the economies of scale and economies of agglomeration. Hence, there is a continuous rise in industrial pollution in urban areas. Also, industries, by locating in the megacities, are directly linking themselves to the global economy and facilitating globalization, international trade and thus, their competitiveness. Finally, industrial pollution directly affects human health, productivity of labour and amenities.

The degree to which individuals’ health and productivity are affected by industrial pollution is a function of two main factors. First, the type and geographic concentration of industries and second, the population density of the area exposed i.e., megacities (supra).

As mentioned in Chapter 2, there is a correlation between the level of development and the nature and composition of pollution flows. Growth usually occurs first with the development of industries like textiles and clothing and food and beverages. These industries have a relatively low pollution intensity (compared to toxic pollution) unless they are highly concentrated in an economy. For example, Thailand and Indonesia are resource rich and facilitate the development of large resource-based industries like food processing. The concentration of

these industries causes high levels of pollution - often in the form of wastewater and sludge affecting BOD/COD levels in waterways.

The second phase of development includes the flourishing of heavy polluting industries to wit, ferrous and non-ferrous metals, petrochemicals and non-metallic minerals (e.g. cement and glass). In addition to water contamination, air pollution rises as toxic chemicals and heavy metals are released. Finally, pollution intensity appears to decline and/or to be modified as an economy moves into the third phase and focuses on the production of electronic/electrical equipment, general machinery, transport equipment and services. Though services are relatively pollution free activities, this stage seems to be accompanied by an increase in hazardous wastes problems as well as an increase in consumer-related pollution i.e., electrical energy consumption, synthetic detergents, CFCs in refrigerators and air conditioners, fossil fuel consumption in motor vehicles etc..

There is a high concentration of industries in the megacities. This concentration has been critical in urban environmental degradation. In order to curtail pollution it is therefore, necessary to ascertain which industries are the most polluting in the megacities. The question then is what, and whose, criteria should be used to determine which industries are “dirty” industries? Many difficulties arise in attempting to answer this question. First, our analysis requires comparable data. This is difficult as each country has different environmental standards and regulations, social preferences and are at different stages of economic development. Also, relevant criteria and data may be lacking. An alternative is to analyze one of the most advanced sets of environmental criteria established to date that is to say, the United States Environmental Protection Agency’s Toxics Release Inventory (TRI), 1987-1994. though directly applying industrialized country criteria to developing countries may not always be the most appropriate means of comparison, it is a starting point.

The Toxics Release Inventory (TRI) includes 343 chemicals and 22 chemical categories. In 1994, 22,744 facilities in the United States filed 75,332 forms with the EPA for the Inventory, listing all chemicals they manufacture, process or use in excess of reporting thresholds. The results indicated that facilities released, on-site, 2.26 billion pounds (pds) of listed toxic chemicals in 1994, of which 68.8% was released into the air, 15.4% was injected underground, 12.8% was on land and 2.9% was discarded in surface water. The report equally gathers data on off-site transfers i.e., chemicals that are moved to other locations for recycling, energy recovery,

92However, it does not include SPM, CO2 nor NOx.
treatment or disposal. Off-site transfers in 1994 totalled 3.8 billion of which 64% was recycled, 12.2% went into energy recovery, 8.4% went for treatment, 7.8% was disposed and 6.7% was transferred to publicly owned treatment works.\textsuperscript{95}

Two important questions are relevant for our study. First, which industries form the target set? Second, which chemicals are being considered? In the first case, manufacturing facilities in SIC codes 20 through 39 comprise the TRI set (see Table 4.5). It was found that the 10 most polluting industries are: chemicals, primary metals, paper, transportation equipment, plastics, fabricated metals, petroleum, furniture, printing and those covering multiple codes (see table 4.6).\textsuperscript{96} The industries generating the most toxic chemicals in production-related waste in 1994 were: chemicals, primary metals, paper, petroleum, stone/clay/glass, fabricated metals, electrical, plastics, transportation equipment and multiple codes.\textsuperscript{97} It is assumed here that these same industries shall be the most polluting industries in South Korea, Thailand and Indonesia, provided that these industries exist in these countries. Also, other industries, such as textiles or footwear, are equally highly polluting and are found in abundance in our country case studies thus, changing the composition and density of industries in the capital cities. Consequently, some variations in polluting industries and toxic chemicals may exist.

The TRI Report, as mentioned, tracks 343 chemicals. However, the study does classify the top 10 chemicals released by media i.e., air, surface water, underground injection and land (see Table 4.7). It also lists the potential adverse human health and environmental effects of the top 25 TRI chemicals with the largest air/water/land releases for 1994 (see Table 4.8). It is presumed that if the same set of polluting industries are to be found in the three case studies, approximately the same set of the top chemicals released shall be found. Again, variations may exist where polluting industries differ, production processes vary etc.. The release of metals and metal compounds, mainly by the primary metals industry, also has potential adverse human health and environmental effects (see Table 4.9).\textsuperscript{98}

Another area of concern is those industries which are ozone depleters. Of the SIC 20-39 industry codes, those U.S. industries emitting the greatest amount of ozone depleting substances were: chemicals, plastics, transportation equipment, and multiple codes. The total air emission levels in 1994 ranged from 18.6 million

\textsuperscript{95}USEPA, (1996), pp. ES-4-5.
\textsuperscript{96}This includes total releases and transfers. The most polluting multiple two-digit SIC codes are 28 and 20 (chemicals and food); 29 and 28 (petroleum and chemicals); 26 and 28 (paper and chemicals); 26 and 24 (paper and lumber). See USEPA, (1996), p. 35 for a list of the top 25 combinations of multiple two-digit SIC codes for TRI Releases, 1994.
\textsuperscript{98}USEPA, (1996), pp. 56-62. Primary metals accounted for 76.3% of total air/water/land releases of metals and metal compounds in 1994; chemicals for 13.2%, paper for 1.6%; multiple codes 2.8%; no codes 3.3%; all others, 2.9%.
pounds for chemicals to 9.5 million pounds for multiple codes. A second tier of heavy emitters of ozone depleting substances were electrical equipment (5.8 million pounds), fabricated metals (4.8 million pounds), machinery (3.7), and primary metals with 1.9 million pounds. The remaining industries had less than 1 million pounds per industry. 99

Finally, the TRI Report analyzes known or suspected carcinogens by industry. The most hazardous industries in this category are: plastics, chemicals, paper, transportation equipment, and those with multiple codes. 100

Hence, for our study, an approach would be to pick the top polluting industries indicated by the TRI e.g., chemicals (SIC 28), primary metals (SIC 33), electrical (SIC 36) and fabricated metals (SIC 34) and compare them across the three cities of Seoul, Bangkok and Jakarta. However, as we know, the three export-oriented countries under study are not at the same level of development and have differing revealed comparative advantages (Table 3.1b). Hence, their economies may not be composed of the same industries or these industries may not account for a large share of manufacturing value added or they may not be highly concentrated in the megacities, in which case their contribution to urban environmental degradation would be small. Consequently, a different, tailor-made approach may be necessary for each country. Nevertheless, a close correlation between polluting industries and existing industries shall be attempted across countries in order to provide some comparable data. The methodology for gathering relevant corporate data is surveys and interviews. These surveys shall determine, among other things, the pollutants emitted by the companies. This shall be achieved through a single list of the top (TRI) toxic chemicals, metals, ozone depleters, and carcinogens.

4.4 The Megacities’ Industries and Environmental Technology

The three Asian megacities have had rapid industrialization and effervescent urbanization grafted to their frail infrastructures. The outcome is visible and palatable for millions of urbanites: urban environmental degradation. In this section, we shall focus on the megacities’ polluting industries and what is being attempted by domestic corporations i.e., development and trade of environmental technology, to alleviate pollution. Our first step shall be to analyze the specific factors influencing industrial wastes in the Asian megacities. Second, we shall proceed with a more minute analysis of selected companies within the metropolises. This research shall provide us with an insight into industries’ efforts at sustainable development, as well as competitiveness in the international economy - both aspects being essential for their respective country’s future development.

Industrial discharges and wastes are influenced by five main factors:

1) scale of manufacturing activity
2) structure of manufacturing sector
3) location/concentration
4) process and production methods
5) pollution abatement technology.\textsuperscript{101}

Since the mid-1980s Thailand and Indonesia have experienced rapid growth in their manufacturing sectors. Indeed, Thai manufacturing growth during the period 1986-1992 exceeded 15% per year, “almost one and a half times faster than GDP growth”.\textsuperscript{102} The result has been an increase in the share of manufacturing in GDP from 22% in 1980 to 29% in 1994. For Indonesia these figures are 13% in 1980 and 24% in 1994. Korea’s manufacturing sector has maintained a 29% share of GDP for the same time period. Indeed, in order to find a significant differential in manufacturing’s share of GDP it is necessary to go back to its development phases of the 1960s and 1970s.\textsuperscript{103} For Thailand and Indonesia, these significant increases in manufacturing’s share of GDP has engendered increases in the number of manufacturing firms. In Thailand there are over 52,000 firms and 23 industrial estates. Korea classifies industrial facilities according to the amount of fuel consumption at each facility for air pollution and according to size for industrial wastewater sources. At the end of 1994, there were 28,090 facilities which were “classified as air pollutant generating business establishments and (were) subject to control”.\textsuperscript{104} Industrial wastewater facilities totalled 28,574 sites, which represents a 5.7% increase since 1993.\textsuperscript{105}

We have equally underlined the structural change within the manufacturing sector of these countries (supra Chapter 2). Korea has attained the maturity stage of capital and technology intensive processes as well as services, which are less polluting. Thailand is in a transitional phase between the second stage of labour-intensive activities and the capital and technology intensive processes. However, because it does have a rich natural resource base, processing industries are an important aspect of its economy. Indonesia is currently moving from stage one of processing and resource-based activities to the labour-intensive activities stage.

Industrial activity can be broken down into two main branches. On the one hand there is materials-

\textsuperscript{100}USEPA, (1996), p.76.
\textsuperscript{101}World Bank, (1994crb), p. 130.
\textsuperscript{102}World Bank, (1994crb), p. 130.
processing industries like food processing, textiles, chemicals, metal products and machinery, wood products, basic metals non-metallic minerals and paper products.¹⁰⁶ These emit high pollution loads and can be considered as the more polluting industries. On the other hand, there are assembly industries which are relatively less polluting but which can cause safety hazards to workers. Table (4.10) gives an assessment of pollution intensities of both processing and assembly industries in Indonesia. It reveals that, whether considering “new” or “traditional” pollutants, the processing industries are still more pollution intensive than assembly industries. The only exception being volatile organic compounds (VOCs). The share of materials-processing industries in the three economies is substantial. According to the World Bank, the top 5 air polluting industries in Indonesia account for 86.2% of pollutants. For water pollution that figure is 98.9% BOD and hazardous wastes amount to 62.9% for the top five industries (Table 4.11). These industries are mainly processing industries. As for Thailand, Table (4.12) indicates that polluting industries make a relatively significant contribution to manufacturing value added and are projected to increase in the upcoming years. These industries are equally process activities. In addition, these export-oriented countries have a revealed comparative advantage (RCA) in polluting, processing industries. Table (3.1b) demonstrates that in 1994 Korea had a RCA in such polluting industries as textiles, garments, footwear, leather, rubber, and metals. Both Thailand and Indonesia have RCAs in the following polluting industries: food processing, manufacturing textiles, garments, leather, and furniture. Thailand also had a RCA in rubber, stone, clay, glass and related items. Indonesia’s large petroleum resource gives it a RCA in all petroleum related products.

The locational and concentration factor affecting industrial pollution is the focus of our study and an essential aspect for the urban populations of the primate cities as well as for their respective countries’ economies. In Thailand, over 75% of manufacturing value added originates in the BMR and over one half of the 52,000 manufacturing firms are located in the BMR.¹⁰⁷ Air polluting industries registered with Thailand’s Department of Industrial Works numbered 8,120 in 1989. This was a significant increase from the 1969 figure of 68 or even the 1979 figure of 2,241.¹⁰⁸ It was estimated that in 1988, industry’s share of SPM emissions in the BMR was 35%. This was exceeded by the residential and commercial sectors which had 41.7%. The transportation sector contributed 22.3%. Industry’s share of SO2 emissions in the BMR for the same year was 42.6% followed by transportation with 38.7% and power generation, 16%.¹⁰⁹ A more recent study indicates that

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in addition to SPM, industries are also emitting air toxics such as zinc and cadmium. It equally specifies that those industries responsible for the majority of SPM emissions in Thailand are the cement, paper and pulp and chemicals industries.\textsuperscript{110} In Indonesia, the industrial sector is the source of 63% of S0x, 16% of N0x and 15% of SPM.\textsuperscript{111}

In 1994, 26,702 wastewater business establishments were inspected by Korean authorities. Even though only 3,236 (or 12.11%) of those industries are located in Seoul, a total of 6,929, or 25.9% of the industries inspected, are located upstream on the Han River, the water source of the megacity. Industrial wastewater discharges are basically composed of high BOD loads and toxic organic and inorganic chemical effluents. In Thailand, there are 20,221 “factories registered with the Department of Industrial Works (DIW) (which) are classified as water-polluting industries”.\textsuperscript{112} The large generators of waste in Thailand include: food and brewing, paper and pulp, beverage and textiles as well as rubber and tannery industries.\textsuperscript{113} Industrial BOD load is a significant problem but domestic sewerage contributes the most to this problem. Other manufacturing related water pollutants are more chemical based and include heavy metals, oil and grease, phenolics and organic solvents.\textsuperscript{114}

Like in Thailand, BOD load in Indonesia is mainly generated by the domestic sector i.e., 73% of total load. Commercial establishments contribute 12% of the total load and industries, 15%.\textsuperscript{115} However, “monitoring in the Jabotabek area indicates that industries account for 84 tons per day of BOD out of a total of 171 tpd”.\textsuperscript{116} It should also be noted that “Java’s share in the total load of traditional water and air pollutants will decline from 60% to under 45% between 1990 and 2020, in absolute terms these pollutants will expand about 8-fold from the currently relatively high levels”.\textsuperscript{117} There are at least two reasons for this relative decline in pollution. First, assembly-line industries are locating in Java where the labour is more skilled, and these industries are, in general, less polluting than process industries. Second, the other islands are becoming more

\textsuperscript{111}World Bank (1994cra), p. 73.
\textsuperscript{112}Sachasinh, R., et. al., (1992), pp. 24, 95. The number of registered water polluting industries in 1969 was 159, and in 1979, 5,393. The number of registered industries that were both air and water polluting rose from 211 in 1969 to 7,030 in 1979 to reach 26,236 in 1989.
\textsuperscript{115}World Bank, (1994cra) p. 70.
\textsuperscript{116}World Bank, (1994cra), p. 76.
The number of hazardous waste producing industries in Thailand has equally increased over the years. The number of registered industries in this category was at 248 in 1969 and escalated to 7,183 in 1979 to attain 17,057 in 1989. Ninety percent of all hazardous wastes in Thailand is generated by the manufacturing industry. Total waste is approximately 2 million tons per year and is estimated to be at 5.9 million tons per year by the turn of the century. The industries which are projected to contribute the most hazardous waste in the coming years are the “metals industry, transport equipment and machinery manufacture, and the chemicals, textiles, rubber, paper and pulp, and electrical machinery industries”.

In Indonesia, it is expected that in the next 25 years urban population shall double, industrial pollution in urban areas shall have a 10-fold increase but perhaps even more importantly, bio-accumulative metals shall increase 19-fold. Hence, without any enforcement of government policies, urbanites risk being exposed to high levels of hazardous wastes.

Hazardous waste generation in Korea is equally a problem. Indeed, in 1989, it was estimated that 57,645 tons of industrial wastes were generated per day from 9,822 industrial facilities of which 4% were designated as hazardous wastes necessitating special treatment. The wastes generated were: “toxic wastes, waste oils, waste synthetic materials, waste acid and alkali”.

Of the aforementioned five facets affecting industrial wastes, it is factors four, production and process methods, and five, environmental technology, which are the more “flexible” determinants. These can enable firms and countries to alleviate pollution in the cities. It is with these elements in mind that the corporate case studies were undertaken. Indeed, with a methodology of surveys and interviews it was attempted to determine what are the current methods of production which are causing pollution and what technologies these firms are using to alleviate pollution. However, before analyzing the case studies, there is one additional element affecting the quality of environment which needs to be acknowledged.

A significant factor related to PPMs and technology, and consequently, to the quality of the environment, is foreign direct investment (FDI). Investment, both foreign and domestic, can influence the environment in several ways. First, investment influences the vintage of capital equipment used in industries. Countries that are currently receiving large amounts of FDI, like Thailand and Indonesia, shall have newer, and

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most likely, cleaner, more efficient and less energy intensive, capital equipment. This equipment, which has probably been developed in the industrialized countries, shall conform to more stringent standards and entail second generation environmental technology.\footnote{World Bank, (1994crb), p. 7.}

FDI, and domestic investment, can influence pollution depending on the industrial sector it is invested in i.e., if investment flows into the more polluting industries such as chemicals or metals rather than the cleaner sectors. However, as mentioned, new investment means new capital equipment even for the more polluting industries. These cleaner production processes and second generation environmental technology can eliminate a portion of the pollution that may have been emitted had the “dirty” industry facilities been older. Indeed, it is essential to note that in Indonesia, “by the year 2010, assuming continued rapid growth, existing firms will represent only about 15% of total industrial output and, by the year 2020, less than 8%.”\footnote{World Bank, (1994cra), pp. xvi, 29.} Hence, Indonesia shall have newer vintage industries and technology - in both “clean” and “dirty” industries.

During the period 1967-1995, Japan was the largest investor in Indonesia with one third of total realised FDI, followed by the Asian NIEs with one fourth and then the USA and Europe. Perhaps more interesting is the breakdown by economic sector. The primary sector (mining, forestry and fishery) shows the higher rates of realisation compared to the other sectors. This sector entails more “traditional” loads of pollution. However, in the manufacturing sector those industries which had high realisation rates were textiles, basic metals, metals and pharmaceuticals.\footnote{Roesad, K., et al., (1996), p. 41.} These sectors involve a second, more toxic, level of pollutants. Hence, there is an overlap of “traditional” and more “modern” pollutants compounding environmental degradation. This makes government’s and industries’ tasks even more arduous.

In order to get a firmer grasp of the reality of business and environment in the megacities, it was esteemed necessary to go beyond the general picture given above and attempt individual corporate case studies within the limits of the aforementioned polluting industries criteria. Choosing a few companies out of the multitude is, obviously, a delicate course of action to take and entails its own deficiencies. Further case studies are necessary to (dis)confirm the results of the current findings. However, the confinements of time and space have made it compelling to restrain the extent of the current research. Also, this working paper is limited to the Korean case study as at the time of writing this was the only field research that was completed. The final version shall include the case studies of Thailand and Indonesia.

The interviews and surveys were carried out on two levels. First, as companies do not operate in a vacuum, a thorough study of government’s role in promoting environmental technology was undertaken. Here, all ministries involved in some aspect of environmental technology were consulted. The results indicate that government is actively seeking to overcome the barriers to the trade of environmental technology (infra Chapter 5) and are taking measures to facilitate such trade. In addition, government has initiated joint programs with the private sector to develop environmental technology (infra Chapter 6).

Second, specific corporations were interviewed. The choice of companies revealed itself to be very difficult. It was first decided to eliminate small and medium size firms, even though they are a significant source of pollution, since they have the most difficulty in complying with environmental regulations and standards (supra Chapter 3). Also, Korean economic development flourished with the extensive participation of large enterprises, or chaebols. A closer analysis of the main large enterprises led to the selection of two corporations, both of which are the only Korean members of the World Business Council for Sustainable Development located in Geneva, Switzerland. These corporations are: the LG Group and Samsung. In addition, both of these corporations are conglomerates of many companies, including some which would be labelled “dirty industries”.

The LG Group was founded in 1947 and is formed of two main companies, Lucky and Goldstar. In 1995, the corporation changed its name to the new identity, LG Group. The corporation spans six business fields notably, chemicals and energy, electric and electronics, machinery and metals, trade and services, finance and public services/sports. The LG Group achieved $64 billion in revenues in 1995 and the group “today comprises 10% of Korea’s GNP”.\footnote{LG Group, \textit{Annual Report}, (1996).} As our previous investigation has shown, chemicals and metals/machinery are dirty industries. The electronics industry initially used (and still uses?) CFCs in the production/cleaning process of components. These chemicals have been banned by the Montreal Protocol. How developing countries cope with this new international requirement i.e., whether they take advantage of their timelag or attempt to use substitutes early on, is of considerable interest.

LG Chemicals produces a full line of industrial chemical products including vinyl chloride monomer (VCM), polyvinyl chloride (PVC), PE, styrene compound resins, advanced engineering plastics, specialty chemical products and industrial and building materials. It equally has a naphtha cracking center, a benzene plant, a silicon wafers production plant as well as other petrochemical related sites and products.\footnote{LG Group, \textit{Annual Report}, (1996).} The machinery and metals division of the LG Group is mainly involved in supplying basic materials and entire systems for telecommunications and electrical power transmission. The division also includes nonferrous metal
smelting and base-materials. They produce electrolytic copper cathode, process precious metals (gold, silver) and produce sulfuric acid for the electronics industry. They equally manufacture over 1,500 products such as air conditioning systems, injection molding machines, agricultural machines, air compressors, papermaking machines and environmental and defense products. LG Electronics manufactures electric and electronic products entailing the whole multimedia spectrum from TV, audio and video systems, computers, informations systems, to thin-film-transistor liquid crystal displays.

The LG Group has a Committee on Environmental Affairs which directs groupwide policies concerning environment, safety and health issues. It is composed of 4 subcommittees: Environmental Technology subcommittee; Environmental Assessment subcommittee; Waste subcommittee; and Safety and Health subcommittee (planned). In addition, each affiliated company possesses its own environmental organization or research institute and each manufacturing site has its own “Environment and Safety Team” for pollution control and safety management.

The LG Group has adopted the following policy: “Environment as a matter of life” and is taking many steps to achieve sustainable development. A sizeable measure has been taken in environmental investment. Indeed, from $150 million in 1992, environmental investment increased to $560 million in 1996. The projected environmental investment for 1997-2000 is $2200 million, of which $230 million shall go to R&D, $570 million to pollution treatment, and the remainder to facility and process improvement (i.e., including clean technology).

Another step is the creation/establishment of the R&D Center for Safety, Health and the Environment of the LG Corporate Institute of Technology. This center aids the chemical, metals/machinery and electronics companies meet environmental regulations and standards. The survey showed that the group uses/produces chemicals, metals and metal compounds, and carcinogens listed in the USEPA Toxic Releases Inventory, e.g., ammonia, toluene, xylene, methyl ethyl ketone, copper compounds, styrene, ethylene, n-Butyl alcohol, sulfuric acid, propylene, silver and silver compounds, gold, benzene, and 1,3 butadiene. These toxics were generally emitted into the air, surface water or stored on site. They were also transferred for energy recovery, or for treatment and disposal by private companies. However, the group is undertaking measures to reduce emissions.

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127Interview with Dr. LEE, Myung-Kyoon, Director, Environmental Research Division, LG Economic Research Institute, November 6, 1997.
128Interview with Dr. YOON, Woon-Young, Senior Research Engineer, R&D Center for Safety, Health and Environment, LG Corporate Institute of Technology, November 8, 1997.
One of these measures is better housekeeping. The corporation devotes about 20% of its environmental effort on this measure. Examples include the recycling of wastewater from petrochemical and chemical plants or the detection of leakages in valve pumps at chemical plants. Another measure is the use of substitutes. In 1996, the group completely substituted CFCs in the electronics industry. Substitutes represent approximately 5% of all environmental measures. The bulk (70%) of green measures is focused on end-of-pipe technology such as, conventional wastewater treatment for chemical coagulation and biological activated sludge or activated carbon column to treat gases and regenerative thermal oxydation (RTO) for gas to save fuel. Finally, an example of clean technology is putting membrane into the dye industry process and separating the untreated raw material which is then recycled. Clean technology only represents 5% of the company’s environmental efforts. The efficiency (reducing or eliminating emissions) of these measures are estimated at approximately: 80% efficiency for better housekeeping measures; 100% for substitutes; 90% for end-of-pipe; and 95% for clean technology.

Other examples of environmental technology development include the wet cake recycle technology for LG Chemical in which they invested $2.3 million. The result is a zero wastewater discharge and 50% reduction in air emissions by 1999 (compared with the 1994 emission level). There is also the fluoric acid wastewater recycle technology in which LG Electronics invested $110,000 and saved $330,000 in 1996 plus an expected savings for 1997 of $1.1 million (Table 4.13).

The total cost of environmental measures for the LG Group was $320 million in 1996, the largest corporate environmental investment in Korea. Also, the majority of these measures have been developed in-house. Only special elements like incinerators are imported from foreign countries. However, the LG Group equally conducts joint research with the Korea Institute of Science and Technology (KIST), of the Ministry of Science and Technology as well as universities.

The survey likewise included what the interviewee perceived as the barriers and means conducive to the acquisition of environmental technology. For both end-of-pipe technology and clean technology it was stated that costs were the foremost barrier. Second came operating and maintenance fees which are high. Finally, there is a lack of information. However, it was also stated that it was not difficult to find companies specialized in environmental technology when the LG Group itself did not have/want to develop in-house technology.

The LG Group is currently attempting to fulfill its in-house consumption of environmental technology via the LG Corporate Institute of Technology. However, it is apparent that the LG Group has perceived the potential market opportunities in the environmental industry sector as they have begun developing sales outside the group to other Korean firms. Also, their current policy is to sell environmental technology to China, Taiwan
and Southeast Asia by the year 2000.

In less than 60 years, the Samsung Group evolved from a small Korean trading company, supplying rice and agricultural commodities to neighboring countries, into a large conglomerate of 35 businesses including chemicals, machinery, construction, textiles, electronics, finance and the automotive industry. Samsung’s overall net income for 1996 was $164 billion. Samsung’s sales are generated mainly by the electronics industry (28.9%), finance (24.7%), with machinery representing 6.6% and chemicals 2.2%. The total for all other independent subgroup affiliates is 37.6%. The Samsung Electronics division is composed of several electronic companies, each with special capabilities. For instance, the Samsung Electronics Co. manufactures a variety of electronic-related products such as semiconductors, computers, telecommunications hardware and finished consumer electronics products. The Samsung Display Devices Co., Ltd. develops multimedia products. Samsung Electro-mechanics Co., Ltd. produces key parts for TVs, capacitators, VCRs, computers and computer peripherals as well as multilayer printed circuit boards, chip devices and optical/thin film components for communications. Samsung Corning Co., Ltd. was first established in 1973 as a joint venture with Corning Inc. The company produces glass for TV picture tubes, and PC monitors, and indium-tin-oxide coated glass for liquid crystal displays. Other Samsung electronic companies include Samsung SDS Co. whose main business is software development, package, sales and management; Hewlett-Packard Korea Co., Ltd., which markets HP computers, instruments, medical diagnosis machines and other equipment; Samsung-GE Medical Systems Co.

Of interest to our study in the machinery group is the Samsung Heavy Industries Co., Ltd. which is involved in shipbuilding and offshore structures, plants and industrial machinery, and construction, including construction equipment. Finally, the chemicals subgroup is composed of the Samsung General Chemicals Co., Ltd. which operates a large petrochemical complex with a naphtha cracking center and 14 downstream plants that produce: ethylene*, propylene*, butadiene*, C4 raffinates, purified terephthalic acid, styrene* monomer, ethylene oxide/ethylene glycol, paraxylene, purified terephthalic acid, low-density polyethylene, ethyl vinyl acetate, linear low-density polyethylene, high-density polyethylene, polypropylene and compounding resins. The Samsung Petrochemical Co., Ltd. (joint venture between Samsung, Amoco and Misui) produces purified terephthalic acid, a raw material for polyester fiber, though it can also be used to produce PET plastics, food and beverage containers, films, pigments, plasticizers and materials for engineering plastics. Samsung Fine Chemicals Co., Ltd. is a urea fertilizer plant and Samsung-BP Chemicals Co., Ltd. produces acetic acid and

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hydrogen which are used to make other products such as vinyl acetate monomer, esters, fibers, pharmaceuticals, PTA solvents, dyes and flavorings.\textsuperscript{131}

In 1992, the year of the United Nations Conference on Environment and Development, Samsung developed the Samsung Environmental Charter stating its goals to eliminate CFCs and to change its industrial fuels to liquid natural gas (LNG). Samsung equally established in 1992 the Samsung Global Environment Research Center (SGERC) which develops environmental policy for the group. In 1996 Samsung publicized its environmental policy through the “Samsung Green Management Declaration”. The declaration states the company’s commitment to the principle of sustainable development and it created a Green Management Committee to lead the company. The main objectives in the declaration include: “implementing even more rigorous internal standards than those already imposed by governments around the world”; conserve energy and resources in all aspects of production and minimize waste (life cycle responsibility); promote employee health and welfare by providing an ideal workplace; satisfy consumers’ right to know; continue R&D in-house; support governmental environmental policies and local initiatives; developing environmental technology. The main motto is the “three no’s”: no pollution, no accidents, no illness. The declaration equally gave general strategies to implement these goals.

The survey conducted at SGERC unveiled that Samsung uses the following chemicals/metals and metal compounds which are listed on the USEPA \textit{Toxic Releases Inventory}: methanol, toluene, exylene, methyl ethyl ketone, 1-1-1 trichloroethylene, ethylene, trichloroethylene, sulfuric acids, copper and copper compounds, lead and lead compounds and nickel and nickel compounds as well as the chemicals listed above with a (*).\textsuperscript{132} Samsung eliminated the use of CFCs in 1995.

Due to the general policy orientation of SGERC, many of the specifics related to pollutants, i.e., where they were emitted, what the company was physically doing to reduce emissions etc., were unknown or only partial elements were given. For example, to the question - into what medium are toxics emitted? The response was only “transferred for recycling”. It was not mentioned whether some pollutants were emitted into the air, surface water or injected underground. The only emissions reduction measure that was indicated was the elimination of CFCs in 1995, which was induced by global market pressures. According to SGERC, until 1994 Samsung mainly focused on end-of-pipe technology such as, wastewater sites or air pollution control. However,
since that time there has been a shift in focus to attempt to develop clean technologies, especially in the electronics industry with again for example, the substitution of CFCs and the development of a new cleaning process i.e., high pressured water. The environmental budget for Samsung was stated to be $250 million/year.

When asked how effective and efficient the environmental measures taken were, only a few answers were given. Their most prized response is the substitution of CFCs with high pressured water which has a 100% efficiency since all CFCs are eliminated. They equally have developed clean technology to increase energy efficiency. On the whole, technical environmental measures are developed in-house, more specifically by Samsung Engineering. However, the group does import core end-of-pipe technology such as incinerators (from Japan and Germany) and wastewater treatment equipment (from the United States, Japan and Germany). The group then provides auxiliary technology to this equipment.

When purchasing substitutes or environmental technology from abroad the group’s main sources are: first, personal contacts; second, environmental technology fairs; third, industrial associations; and finally academic journals and conferences. The greatest barrier to the trade of environmental technology is the cost of the technology. A second barrier mentioned was patents more specifically, their cost. It became apparent in the interview/survey that questions concerning Samsung’s development and probable export of environmental technology would require further probing into the group to wit, interviewing the Samsung Engineering Company’s R&D Center, Environment Division.

Samsung Engineering was inaugurated in 1970 and has since completed over 1000 projects in Korea as well as abroad. In the 1970s, the main focus was building industrial facilities like fertilizer, petroleum refining and petrochemical plants. Since the 1980s, the company has moved into electronics, synthetic fibers, food processing, and industrial plants in areas like energy, power and environment. Concerning the environment, Samsung Engineering has played a spearhead role as the specialized environmental agent of the group by commissioning the Environmental Business Dept in 1975. The R&D Center itself was established in 1987. The mission of the center is the following:

To satisfy internal and external customers for the demand of new technologies, we lead to strengthen the competitiveness on abroad technology and to create the opportunity of a new business by timely providing and assuring the innovative design techniques and process technologies for chemical engineering, energy and environmental fields.  

The services provided by the Samsung Engineering R&D Center in environmental technology development are:

*industrial, municipal, and hazardous wastewater treatment, especially advanced nutrient removal system;
*flue gas desulfurization and denitrification;
*site investigation and remediation design review;
*in-situ and ex-situ soil and sludge remediation.\textsuperscript{134}

The R&D center is organized into 5 groups: R&D Planning/Analysis; Chemical Process Development; Energy System Development; Environmental Technology Development (Water Treatment); and Environmental Technology Development (Waste & Soil which includes air pollution). The work scope is indicated in Annex (4.14). Approximately 70% of their work focuses on end-of-pipe technology and the remainder on clean technology. The budget for the entire R&D center is 5 billion won, two thirds of which is devoted to environmental technology in general i.e., whether it be a clean process in the chemicals division or an end-of-pipe technology within the environmental section. Examples of various environmental technologies developed at the R&D Center are listed in Annex (4.15). Finally, the center carries out environmental auditing for the entire group. This is very important for Samsung as the group follows standards that are approximately 20\% higher than government requirements.\textsuperscript{135}

Similar barriers to the trade of environmental technology were cited as barriers to the creation and development of environmental technology namely, market conservatism. Indeed, it is perceived that companies are hesitant to embark on environmental technology development because the technology has not been proven and hence, shall find few clients. Companies prefer to use proven technology. A second, and related, barrier is the lack of funds. Currently the funds of the R&D center are a percentage of Samsung Engineering’s revenues and ranges between 1.5-2\% of these revenues. Another barrier is the high license fees of environmental technology. Finally, additional manpower at the center would be beneficial as they are only 55 employees in 1997.

Means considered as conducive to the development and trade of environmental technology include the company’s involvement in the Highly Advanced National (HAN) Projects for Environmental Engineering Technology Development as they provide the center with additional funds for research (infra chapter 6). Also, the government’s initiative (1997) to encourage the use of environmental technology through ecolabels has

\textsuperscript{134}Samsung Engineering R&D Center, brochure, p. 9.
\textsuperscript{135}The reasons given for these higher standards were: public relations, pledge to consumers and foreign markets i.e., environmentally friendly producer and products. Interview with SHIN, Byung Chul, Principal Researcher, Samsung Engineering Col, R&D Center, November 10, 1997.
given environmental technology and the center additional weight in company policy. The existence of the Samsung Global Environment Research Center is also considered as a positive element since it lays down the group’s overall environmental policy, which is a justification for the environmental technology that the R&D Center develops. The Center also provides SGERC with supporting technical reports when needed.

The center does perceive the potential market opportunities in the environmental industry sector. They actually do purchase, change and then sell certain technologies. They also use technologies that they have purchased to build plants for other companies (often Samsung becomes the licensee to build “x” plant for another company). They frequently purchase environmental technology from Germany and Japan, and some from the United States. The criteria they use in making these purchases are, in order of importance: the technology; price; experience of that company; and finally government policy as the latter wishes to control the trade balance and hence, they make designate certain countries.

The Samsung R&D Center also develops in-house environmental technology which is then sold to other Korean firms as well as abroad. Examples of recipients of wastewater treatment facilities for chemical factories are Thailand, Indonesia, Malaysia and China (in these cases, the technology is not necessarily 100% Samsung technology but may be imported and/or modified to suit the site). A landmark for the group was the 1997 sale to an United States firm of the Center’s first environmental technology developed solely in-house and sold as a total package (i.e., Samsung is the licensor). The technology is the PenRepII Process in Annex (4.15). Samsung receives 6% of the American firm’s sales.

Finally, the interview was concluded with prospects for the future. It was esteemed that prospects for the group in the environmental industry were good due to two main elements. First, government regulations in Korea are getting stiffer, which is going to require all companies to follow a green path. Second, public relations and the maintenance of an image of an environmentally-friendly company are essential since consumers and the market are the main determinants of the group’s existence.

As we have demonstrated, dirty industries and pollution abound in Bangkok, Jakarta and Seoul. However, and even though it is difficult to generalize from only two case studies, it appears that Korean conglomerates are well aware of environmental problems and are attempting to pursue a sustainable course of action. They are becoming main clients of the Western dominated environmental industry and are equally creating and developing their own environmental technology. They likewise perceive the potential market

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136 A list of Samsung Engineering’s environmental project experiences up to 1997 is available upon request.
opportunities of this business sector and are emerging as suppliers of environmental technology on the global market.

4.5 Conclusion

The rapid industrialization and uncontrolled urbanization maelstrom has engendered vast environmental degradation in Bangkok, Jakarta and Seoul. This pollution is taxing urbanites and governments as they endeavor to cope and alleviate pollution in their capital cities for both humanitarian and economic reasons. The task is enormous as these economies continue to attempt to pursue economic development nay, perhaps even a more sustainable development. This is all the more difficult as many of the engines which drive their economic development are “dirty” industries to wit, chemicals, metals, paper, petroleum, cement/stone/clay/glass, electrical, plastics, food processing, textiles, etc..

Our modest corporate case studies in these megacities reveal that domestic companies are aware of environmental degradation, are attempting to reduce and prevent pollution, and are pursuing sustainable development policies. The driving force behind this keenness and environmental actions is global market pressure to wit, the need to display and forge an environmentally-friendly business approach to gain and maintain consumer fidelity. This has led corporations to invest large amounts of funds to purchase and develop environmental technology. In addition, the prospects of the potential benefits of being the “first movers”, “first” producers, on the environmental market, which is to attain $600 billion by the year 2000\(^\text{137}\), has led these corporations to develop in-house environmental technology with a long term perspective of selling it overseas. A prime example of a “developing” country firm selling “high”, environmental technology to an industrialized country is Samsung’s sale of its PenRep II Process to an American firm.

An overall conclusion which can be drawn is: Being “green” can be equivalent to being competitive, not to mention the additional benefits which accrue to humans as the environmental quality which surrounds them improves to a sustainable level.

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